HERBICIDE MOVEMENT IN CONVENTIONAL AND REDUCED TILLAGE SOILS

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Reduced tillage systems, in which the previous crop's residue is left at the soil surface at planting, are becoming increasingly popular. The USDA Office of Planning and Evaluation (1975) has estimated that by 2010, 95% of the U.S. cropland will be planted using reduced tillage. One of the main advantages of these systems is the conservation of soil water due to greater infiltration and less evaporation. Concern has arisen that the higher soil water contents in reduced tillage systems may lead to more deep drainage and movement of herbicides into groundwater (Hinkle, 1983).

Metribuzin, 4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-trizain-5(4H)-one and alachlor, 2-chloro-N-(2,6-diethylphenyl)-N-(methoxymethyl) acetamide are two commonly used soil applied herbicides. Metribuzin is more soluble in water than alachlor and has been shown to be more mobile in soil than alachlor (Savage, 1976; Wu, 1980). Under reduced tillage, over half the applied metribuzin and alachlor may be intercepted by the crop residue at the soil surface (Banks and Robinson, 1982; Banks and Robinson, 1986). The effect of reduced tillage on the movement of these herbicides in the soil has not been shown. The objective of this study was to determine the effect of tillage, straw cover, and irrigation on movement of metribuzin and alachlor in a field soil.

MATERIALS AND METHODS

A field study was conducted on an Appling coarse sandy loam at the University of Georgia Plant Science Farm near Watkinsville, GA in 1987 and 1988. A factorial strip-split-plot design consisting of tillage, irrigation rates, and straw cover with four replications was used to determine the effect of each on movement and dissipation of metribuzin and alachlor.

The area was disked and seeded to wheat (*Triticum aestivum* L.) the fall previous to experiment establishment. Following harvest in the spring, wheat straw was removed from the field on July 28, 1987 and June 23, 1988. The tillage treatments consisted of conventional tillage (one pass at a 30-cm depth with a moldboard plow and two passes at a 15-cm depth with a disk plow on August 3, 1987 and June 23, 1988) and no tillage. Alachlor at 4.5 kg ai/ha and metribuzin at 1.1 kg ai/ha were applied in 230 L of water carrier/ha to the soil surface after tillage on August 5, 1987 and July 1, 1988. An application of 60 kg/ha of Cl^- as KC1 was separately applied to the soil surface as a tracer for water movement into the soil profile on July 1, 1988. Immediately after chemical applications, wheat straw was uniformly scattered over appropriate plots at a rate of 2800 kg/ha. All plots were irrigated with 1.75 cm of water on the day of chemical application. Two irrigation levels were established by application of 1.75 cm of water either once or twice per week for 40 days. Water was applied with oscillating sprinklers at 0.7 cm/hr on a 30 min on-off schedule to avoid run-off. Rainfall plus irrigation resulted in 21 and 30 cm of water in 1987 and 35 and 46 cm of water in 1988 in the low and high irrigation treatments, respectively.

Soil cores were taken from all plots to a depth of 60 cm at 5, 12, 19, and 40 days after herbicide application (DAA) in 1987, and at 7, 13, 20, and 40 DAA in 1988. Soil cores were also obtained at 2 and 8 DAA from the high irrigation plots in 1987. Cores were separated into bags by depth and plot in the field and frozen within 4 hr.

Metribuzin and alachlor were extracted from the soil each year using diethyl ether and concentrations were determined using a gas chromatograph. Percent recovery varied from 60 to 80% and from 65 to 75% for metribuzin and alachlor, respectively. The lower limits of detectability in the soil were 8 and 31 ppb for metribuzin and alachlor, respectively.

RESULTS AND DISCUSSION

The concentration of Cl^-, alachlor, and metribuzin in 1988, 7 and 20 days after application (DAA), averaged over tillage, cover, and irrigation treatments, are shown in Fig. 1. Chloride moved deeper than either of the herbicides in the first 7 days and continued to move between day 7 and 20. Alachlor and metribuzin did not move any deeper between day 7 and 20 and the concentrations decreased during this period indicating that the herbicides were being degraded. These results show that metribuzin and alachlor were tightly adsorbed by the soil and that most of the movement occurred shortly after application.

To describe movement in terms of depth and concentration, a distribution value (DV) was calculated for each plot and sampling date by multiplying the concentration as a percent of that applied by the sampling depth and summing these values. Treatment effects on herbicide and Cl^- DV's, 7 and 20 DAA in 1988, are shown in table 1. Chloride DV's increased from day 7 to day 20 in all treatments and were significantly greater under high irrigation. Distribution values tended to be higher under straw where evaporation was less and in no-tillage where continuous channels through the plow pan were likely to have occurred. Distribution values for alachlor and metribuzin were much lower than those for Cl^- and decreased from the first sampling date in all treatments. Irrigation did not have an effect on movement of alachlor, but there was a trend toward greater movement of metribuzin under high irrigation. Straw cover increased DV's of metribuzin, but not those of the less mobile alachlor. Tillage increased DV's in alachlor and this may have been due to the greater porosity in the 0-10 cm depth, to which alachlor movement was confined, in the tilled compared to the no-till soil. Metribuzin which moved deeper, was not affected by tillage. Treatment effects were similar on the other sampling dates in 1987 and 1988 (data not shown).

SUMMARY

Movement of metribuzin and alachlor was limited under both conventional and reduced tillage systems, even under heavy irrigation. The maximum depths at which alachlor and metribuzin were detected were 8 and 23 cm, respectively. Most of the movement probably occurred with the first irrigation and the depth of movement was greater for the more mobile metribuzin under straw cover due to reduced evaporative losses. Once the herbicides were adsorbed by the soil, there appeared to be little further movement and changes in concentration were due to herbicide degradation.

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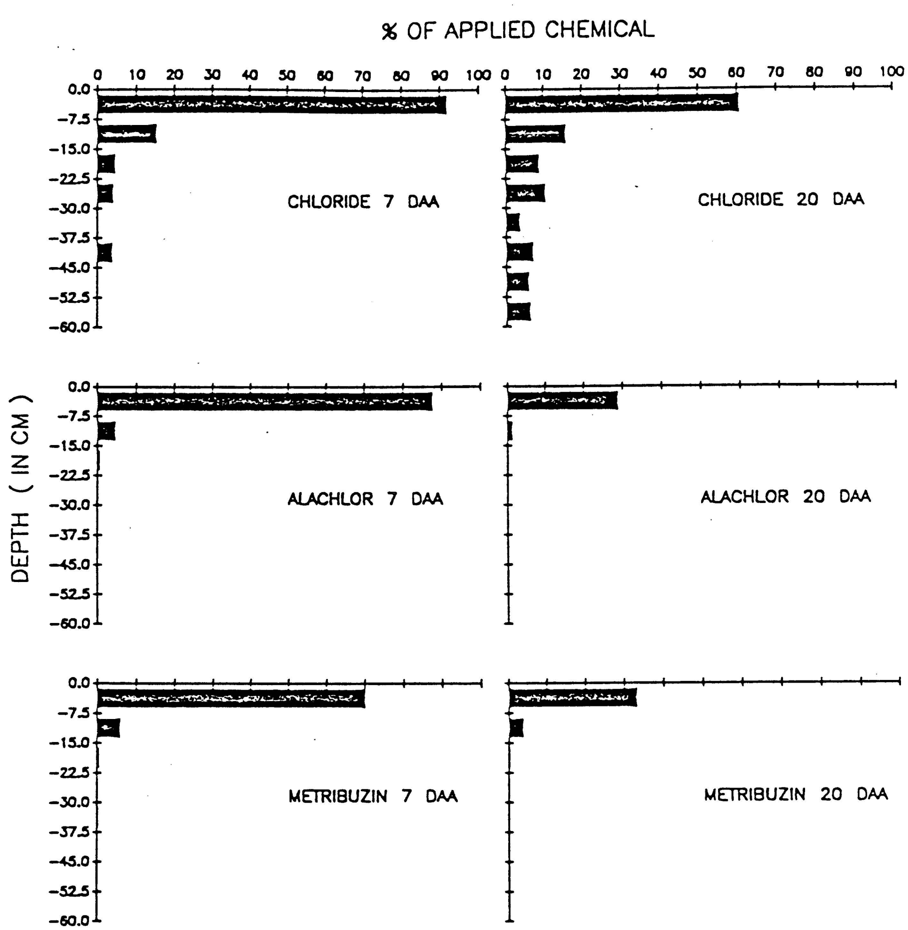

Fig. 1. Concentrations of chloride, alachlor, and metribuzin with depth on 7 and 20 DAA in 1988, averaged over treatments.

Table 1. Distribution values as affected by treatments in 1988.

	Cl^-		Alachlor		Metribuzin	
	7[1]	20	7	20	7	20
Straw cover	980	2009	44	9	76	50
No cover	700	1562	43	13	50	29
pr>F[2]	ns	ns	ns	.061	.008	.092
Tillage	672	1744	48	21	64	32
No-Tillage	1007	1826	2	0	63	46
pr>F	ns	ns	.002	.011	ns	ns
High irrigation	1058	2028	26	11	86	45
Low irrigation	621	1544	24	11	41	34
pr>F	.071	ns	ns	ns	ns	ns

[1] Days after application.

[2] Significance probability - ns denotes no significance at 0.1 alpha level.